

# Postharvest technology of fresh-cut horticultural products

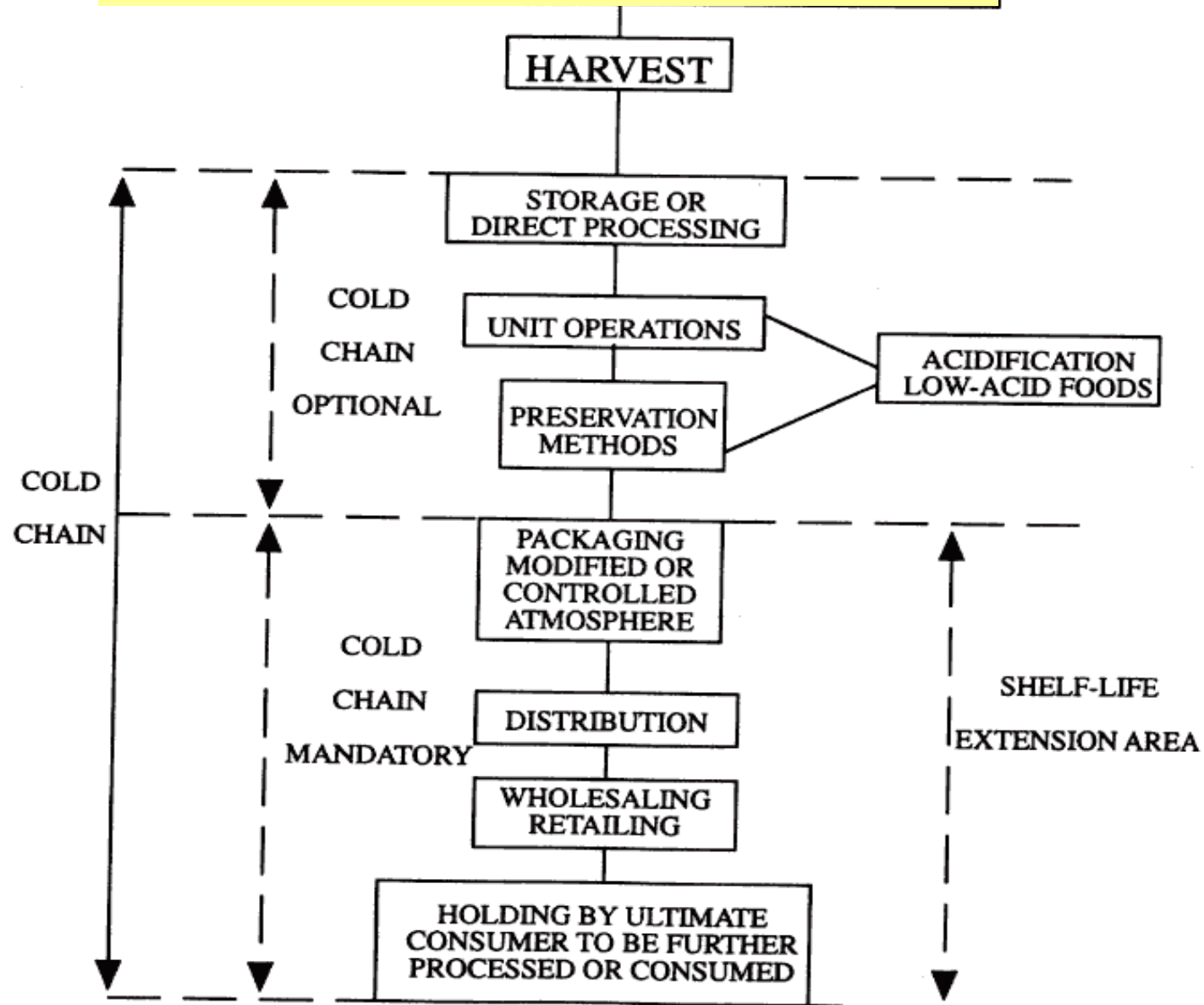


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# FRUITS AND VEGETABLES



## TECHNOLOGY OF PRODUCT PREPARATION





## PROCESSING CONDITIONS



## Leafy vegetables



### Forward-only movement

There should be no "crossing over" in the processing line between the raw product and the clean product

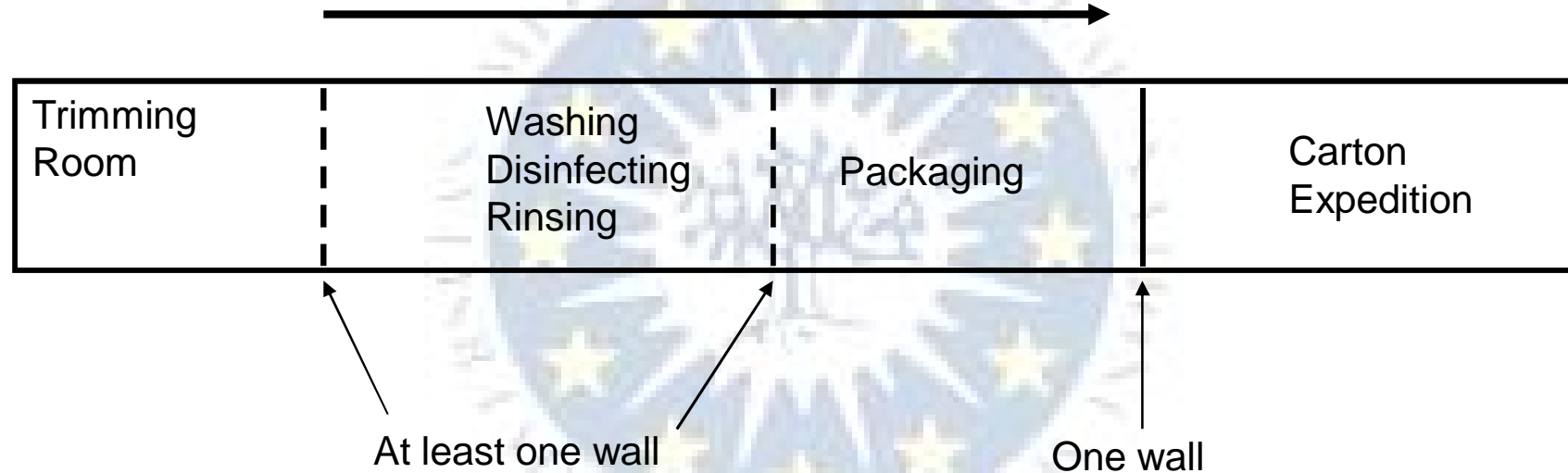


OK



Not acceptable

# Segmentation of the processing line (to prevent cross contamination)



## Temperature gradient and airflow in the processing line

Airflow ← Positive pressure				
Ambient T	12°C → 4°C			4°C
	Washing			
Raw Material	Trimming Prewashing	Disinfecting Rinsing Draining	Packing	Carton Expedition

- Limit exposure to T above 10°C
- Refrigerate the product at 0-2°C before packaging
- Maintain this T during storage



# Airflow

Ventilation system -prevent both condensation and circulation of dust







**Wastes** material evacuated from the facility to avoid any cross-contamination

**Cleaning equipment** washing by any method of combination involving mechanical action or chemical cleaning

**Sanitation** after washing apply steam or chemicals for sanitation

**Hygienic procedure** for operators personnel should follow hygienic procedures, wear protective clothing and footwear

**Chlorinating chlorine** disinfection must be followed by rinsing with portable water (use less than 0.5 ppm active chlorine)

Duration 2 minutes

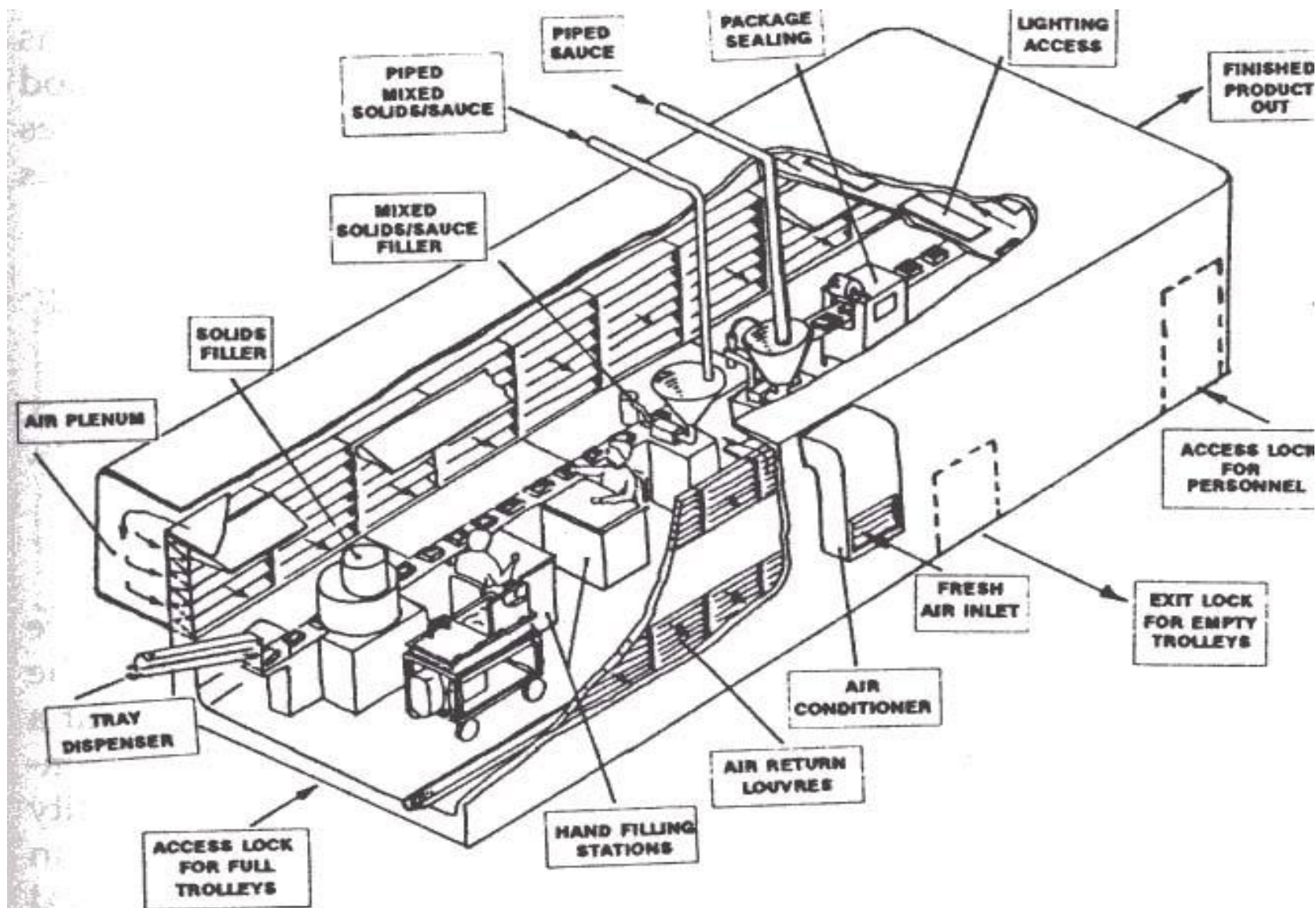
PH of the disinfection solution between 6.5 -8

**Distribution conditions:** chill chain and sell-by-date

Determination of the shelf-life by the processor

*Temperature:* 2/3 of the shelf-life at the prescribed T (4°C) and the remaining at 8°C





Aseptic assembly and packaging room for fresh-cut products



## Raw material

The quality of the raw material is one of the most essential factors determining the quality of the final product. For hygienic reasons, no manure or fertilizers of animal origin should be used.

The main criteria for *suitability of cultivars* to fresh-cut processing are as follows:

- Processing yield
- Low sensitivity to physiological disorders and microbial diseases
- Mechanical resistance of the tissue
- Resistance to elevated CO<sub>2</sub> concentration
- High sugar contents
- Low respiration rate
- Special requirements

## Harvesting

- Cultivars and cultivation techniques
- The salads harvested in the morning
- Produce precooled to 1°C as soon as possible
- Processed within two days





## Quality assessment

### Quality control by:

- appearance,
- overall freshness,
- absence of insects,
- physiological and microbial diseases,
- necrotic tissue,
- pesticide residues and
- nitrate content





## Trimming-cutting- Slicing and shredding

Remove mechanically the unwanted parts (outer leaves, the core)

Wounding---> induces softening (e.g. kiwifruit lose 50% of the initial Fm) and browning

Use sharp knives to minimize injury

After cutting instant washing out of the cell sap liberated by cutting

Slices cut in air and rapidly dipped into water

the longer the interval between cutting and washing, the browner the slices during storage

# TECHNOLOGY OF PRODUCT PREPARATION

## Major unit operation of fresh-cut F&V



### Steps

Harvest

Transport

Cooling

Trim and core

Chop/shred/tear

Wash with chlorinated water

Centrifugation (remove surface moisture)

Package in film

Store temporally ( $<5^{\circ}\text{C}$ )

Transport and distribute to retail markets

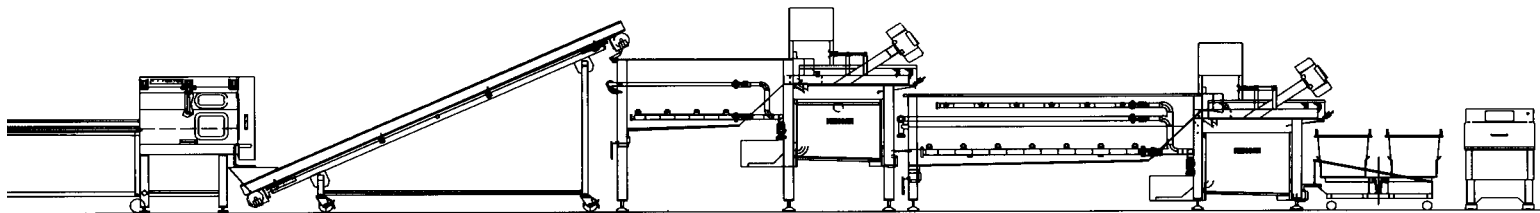
Initial preparation

Cutting

Washing

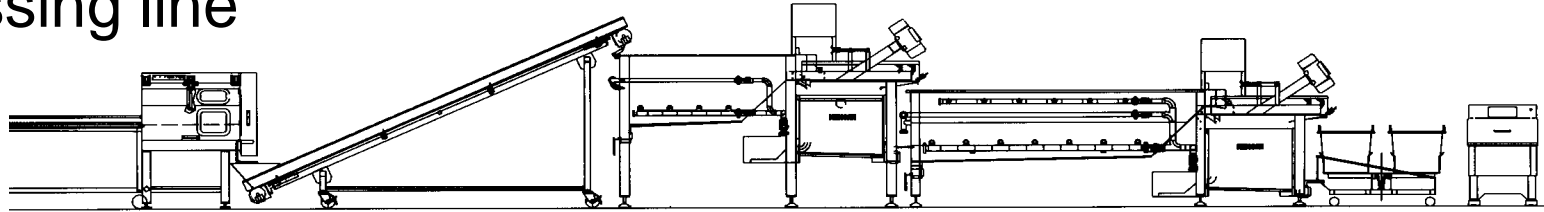
Centrifugation

Packaging



Processing line

# Processing line



## Handling operations

**Objective:** ensure ultimate consumer safety (nutritional and healthy quality, convenience at minimum cost.

Methods involves washing, cutting, rinsing, conditioning, packaging and storage.

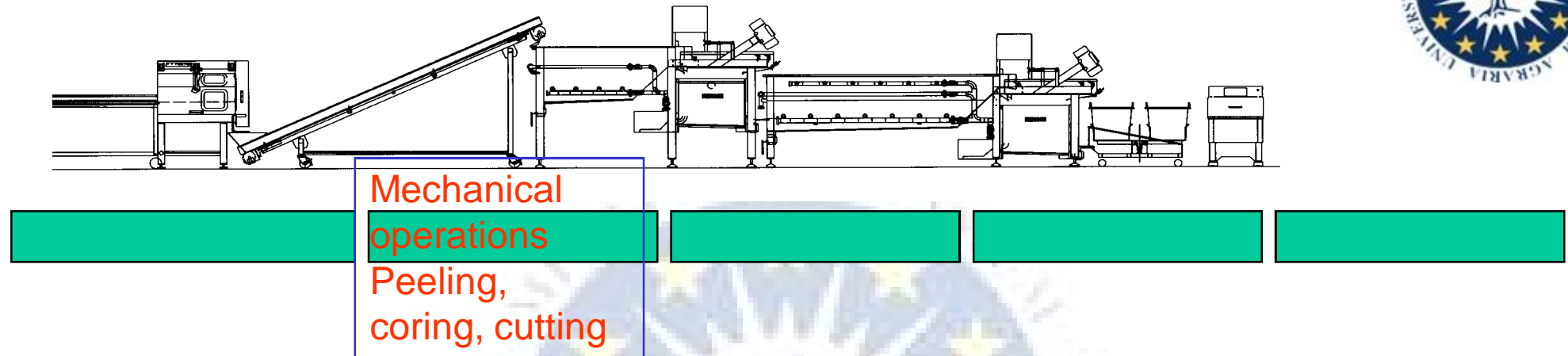
## Design of a processing line

**Consider:**

- Initial investment cost
- Cost of operation
- Time
- Labor employed
- Amount and type of water used



# Processing line

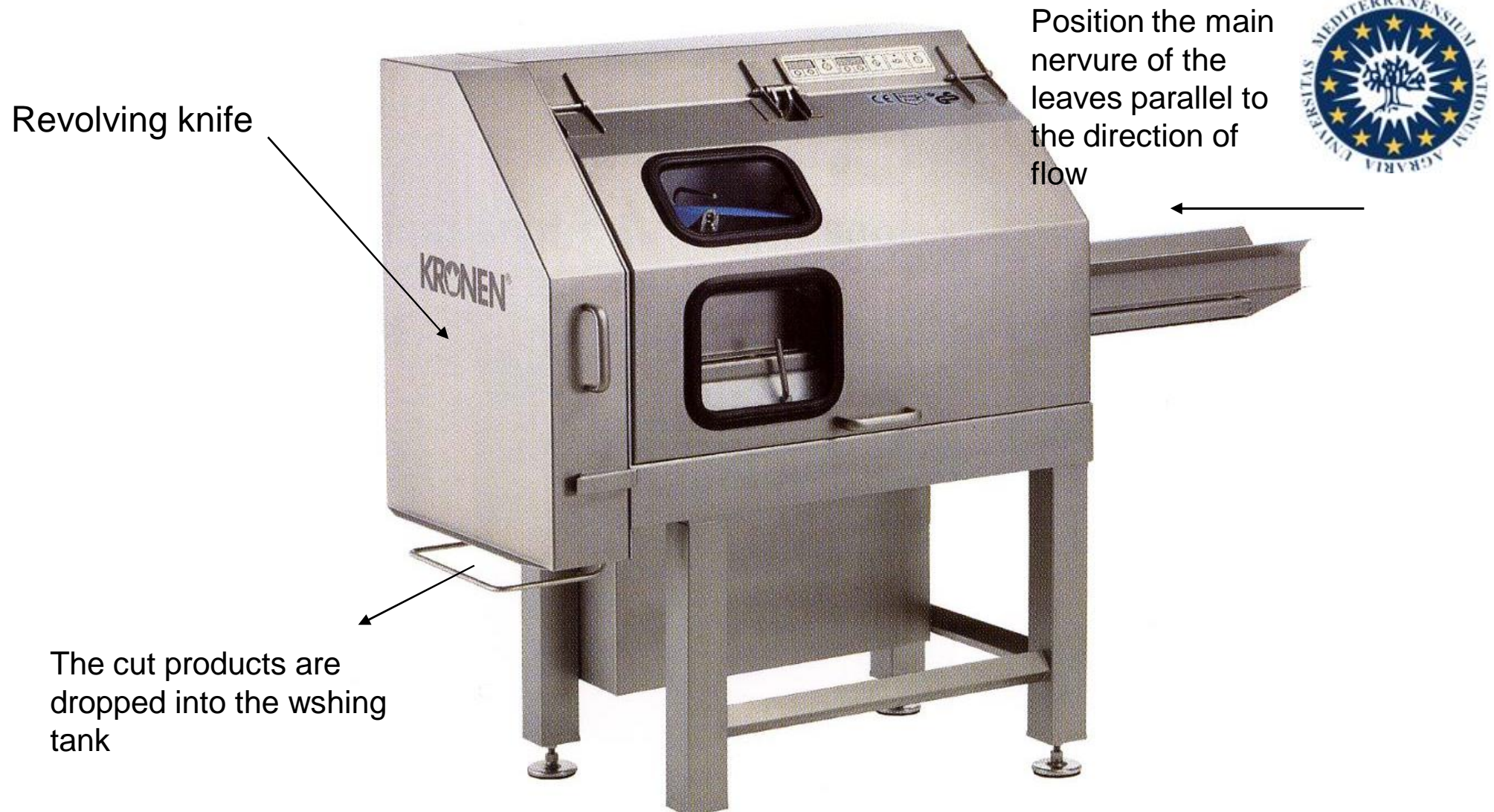


**Cutting**-reducing the size of material

- Accelerates respiration
- Increases ethylene production
- Causes mechanical damage
- Softens plant tissues

Cutting machines for chopping, slicing dicing and shredding of F&V by:

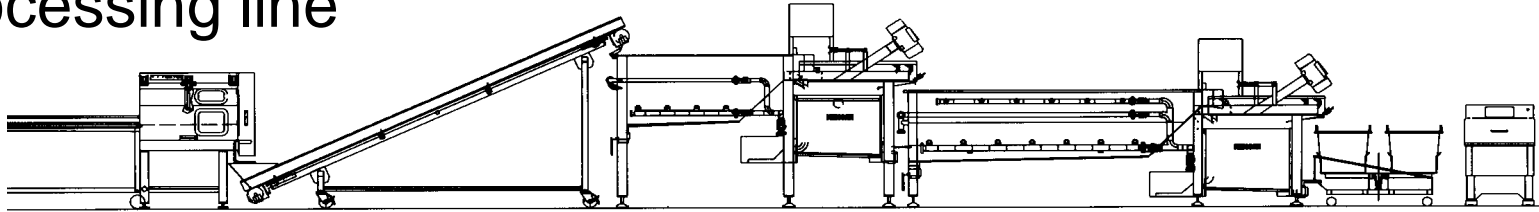
- Slicing knife
- Circular knife
- Crosscut knife
- Water knife (cut by a fine jet of high -pressure water (3000 kPa))



Belt cutter for high volume production

Speed of knife and feed belts -programmable

# Processing line



Prewashing washes away exudates and saps

Washing with chlorinated water

Maximum active chlorine at 120 ppm ---> 80 ppm

not drop below 50 ppm

The current trend is to eliminate chlorine

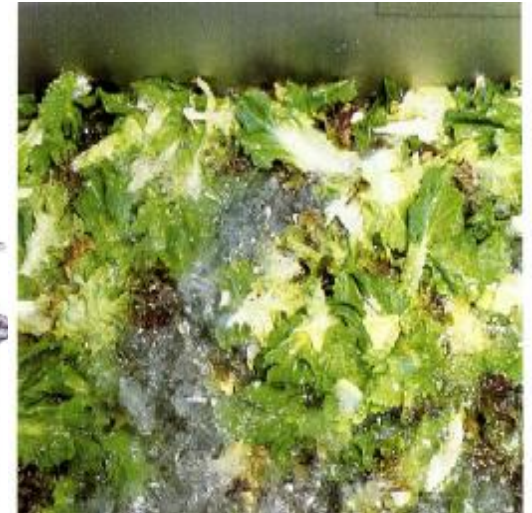
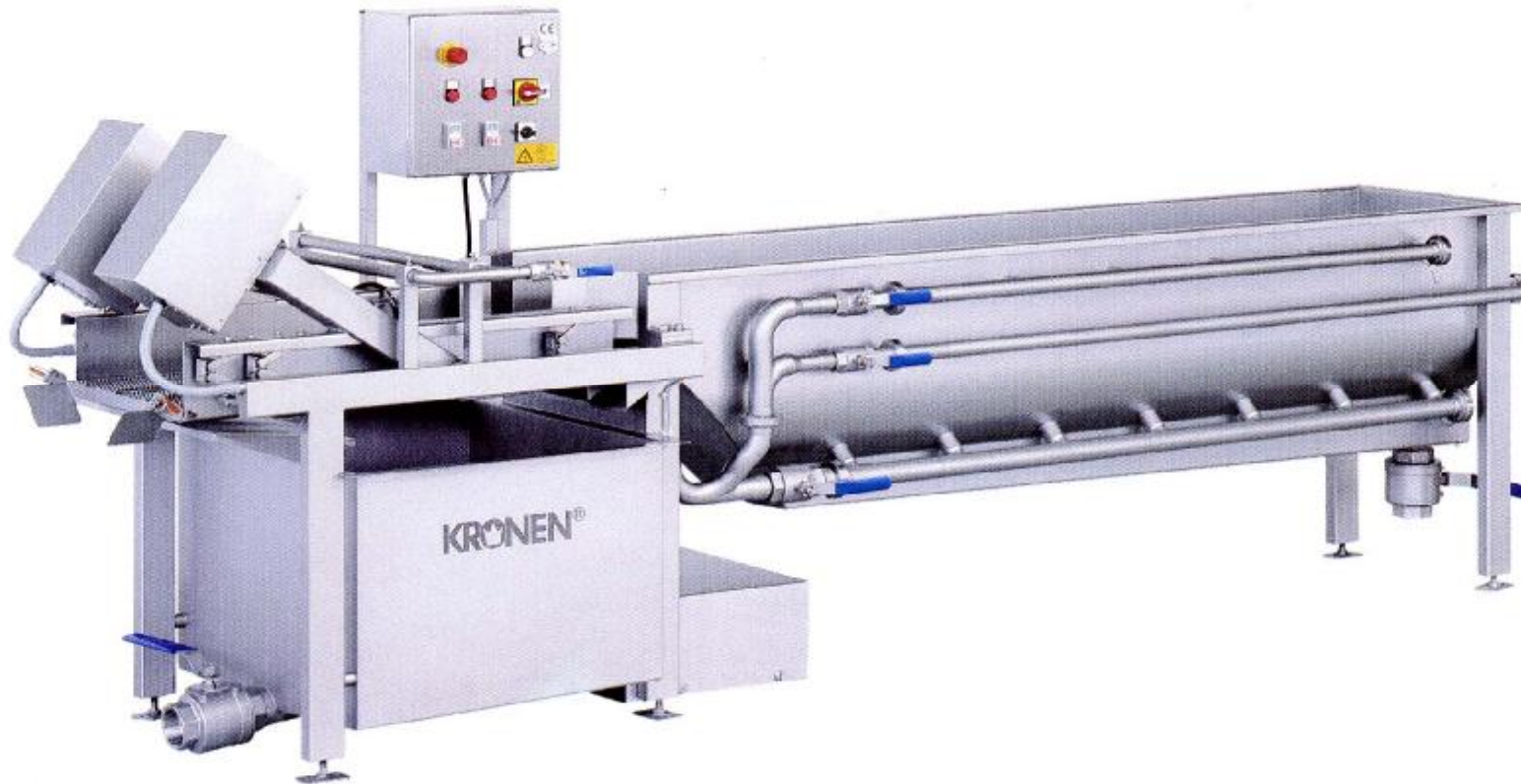
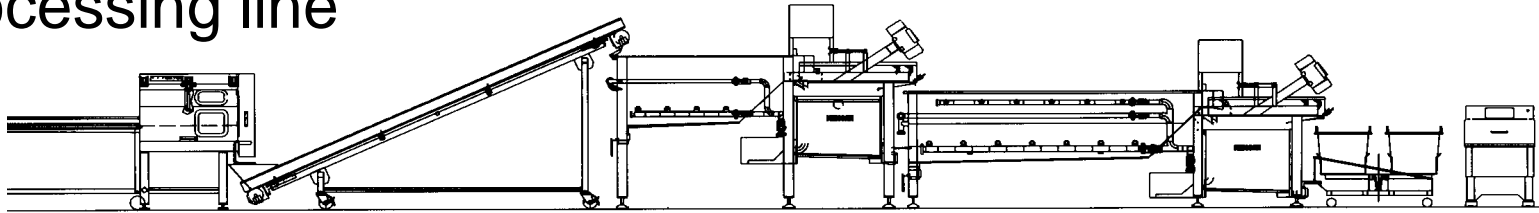
Agitation in the disinfected tank (air bubbling or water circulation)

The last step is a rinsing with tap water

Cold water (1-3°C) continuously renewed to avoid chlorine accumulation



# Processing line



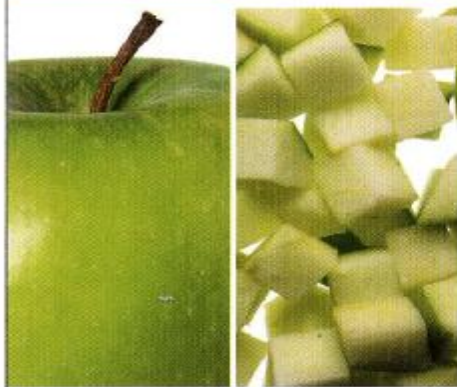
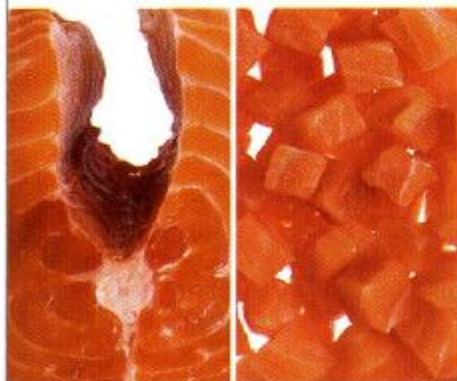
After washing **antioxidants** (ascorbic acid, citric acid) are added



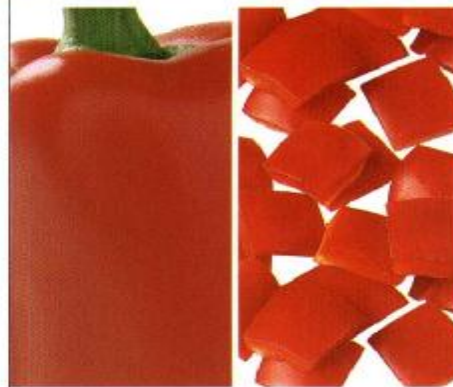
GS Series



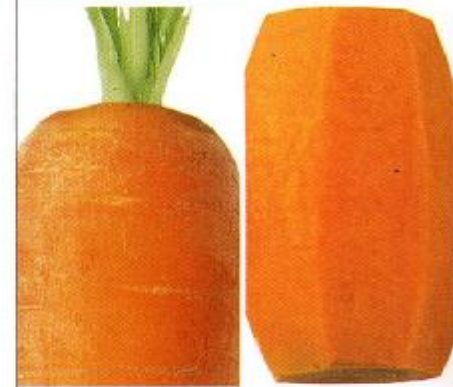
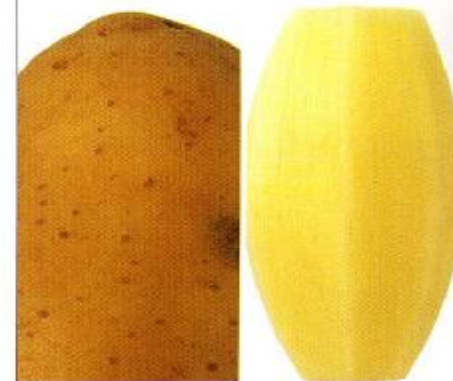
KUJ



GVZ



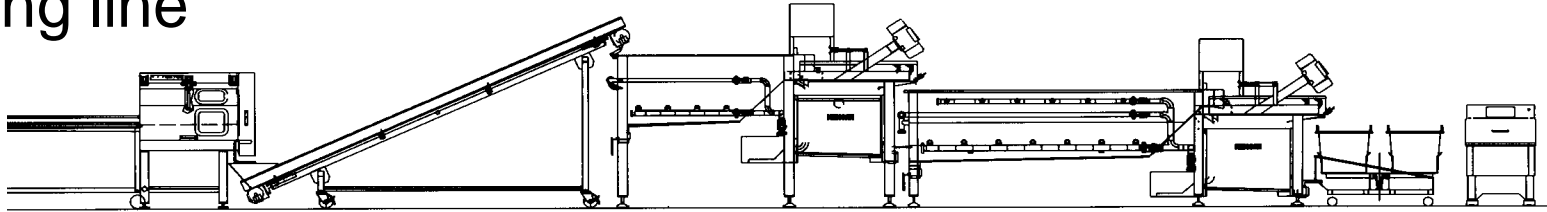
Formit Series



Belt cutters for different products



# Processing line



**Cleaning:** removal of foreign materials(dirt, sand, soil, insects, pesticides etc.)

**Washing** the cut products **remove sugars and other nutrients at** the cut surfaces that favor the microbial growth and tissue discoloration (rinsing cut surfaces to remove released cellular nutrients)

Washing in isolated chambers, restricted entrance, limited contact to produce, the product is ready to eat and ready for preservation.

At this stage **chlorination** free of microorganism (up to 200 ppm)

Quality of water used:

5-10 L/kg product

Concentration of active chlorine 100 mg/L

Chlorination by calcium or sodium hypochlorides (pH ,8.5)

After washing **antioxidants** (ascorbic acid, citric acid) are added



## Washing and sanitizing operations

- Sanitation of the whole fruits with an initial rinse in tap water to eliminate pesticide residues, plant debris and other contamination
- Dipping in **chlorinated water** to reduce the microbial load on fruit surface by adding sodium hypochlorite ( $\text{NaOCl}$ ) to the wash water.

Dips 50 to 200 ppm of added free chlorine for apples.

Chlorine should subsequently be rinsed to eliminate residual chlorine.

The safety of using chlorine has been questioned. Need for alternative ways of sanitizing fresh-cut F&V.

**Hydrogen peroxide** appears promising for fresh-cut F&V as an alternative to chlorine (rinsing immediately after treatment) ?

**Organic acids** (peroxyacetic acid, octanoic acid) are suggested

**Irradiation** to sanitise fruit cut surface ?

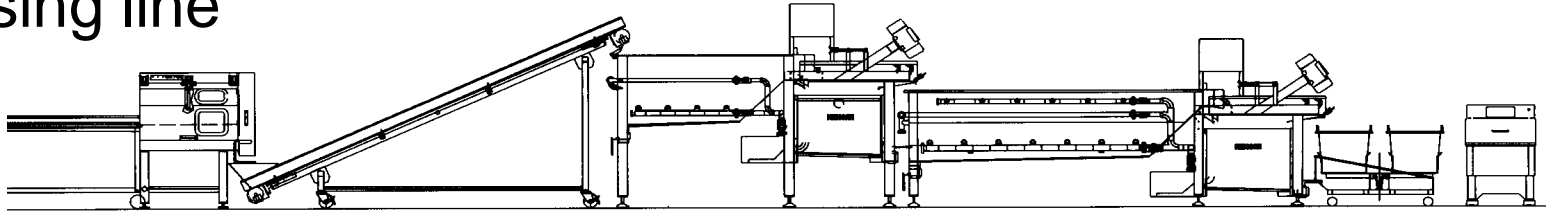


## Dipping treatments

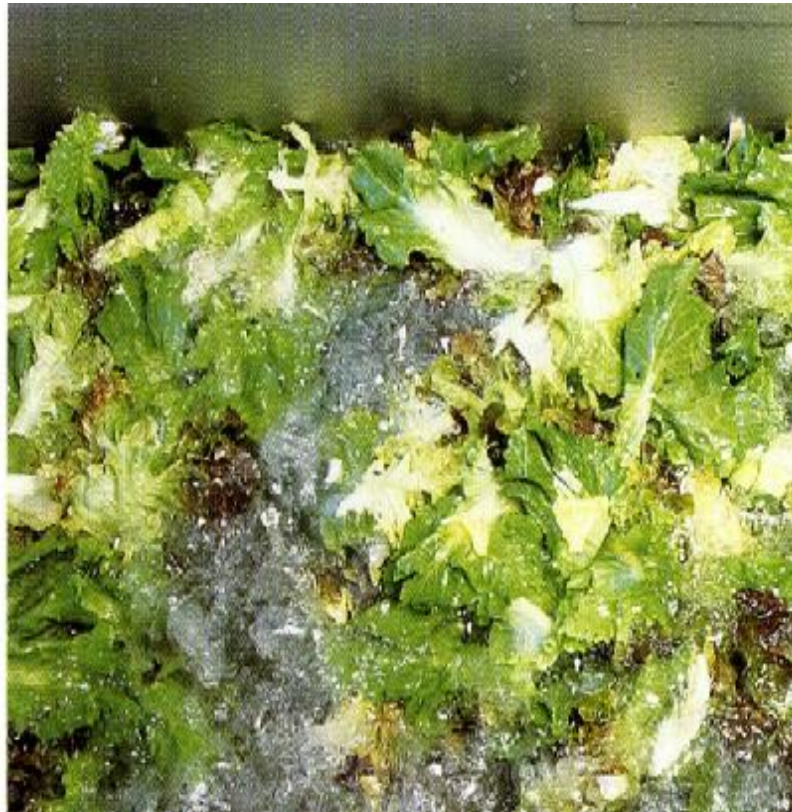
**In fruits** dipping treatments are beneficial because the enzymes and substrates released from injured cells during catting operations are rinsed from the product surface

- **Dipping time** 1 to 5 min
- **High temperature** dipping (20° to 60°C)
- **pH** of the dipping solution (low pH value is recommended-antimicrobial properties)
- **CaCl<sub>2</sub>** dip on fruits have beneficial effects

# Processing line



Washing



After washing **antioxidants** (ascorbic acid, citric acid) are added



## Drying of wet surface

The excess water must be completely dried to avoid problems with microbial spoilage of the fruit surface

Water removal by:

- Draining
- Spinning

**Problem** if not conducted properly-gently --> mechanical bruises.  
The process should remove at least the same amount of that the product retained during processing (slight dessication is better)

# DRAINING



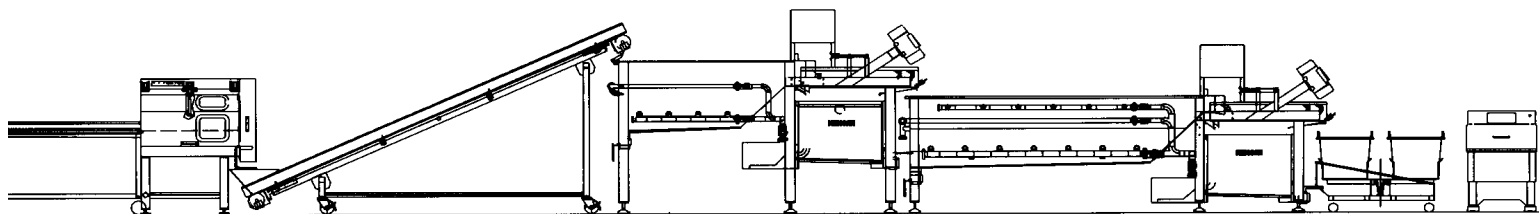
Excessive free water ---> rapid bacterial spoilage

Methods:

*Spin dryer* by centrifugation (soft loading--> smooth acceleration and careful discharge)

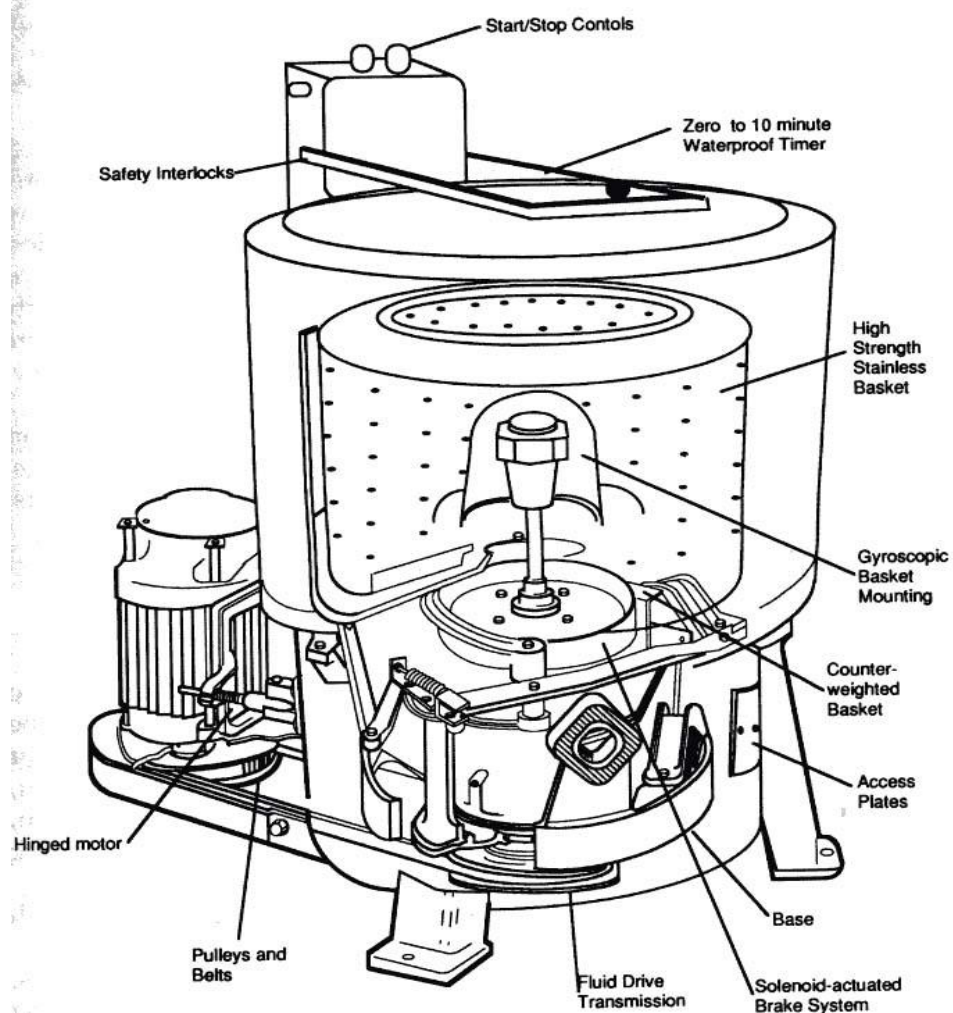
*Air tunnel drying (Italy)* the airflow is filtered and disinfected with a UV (250-280 nm) tube





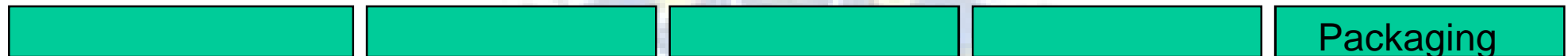
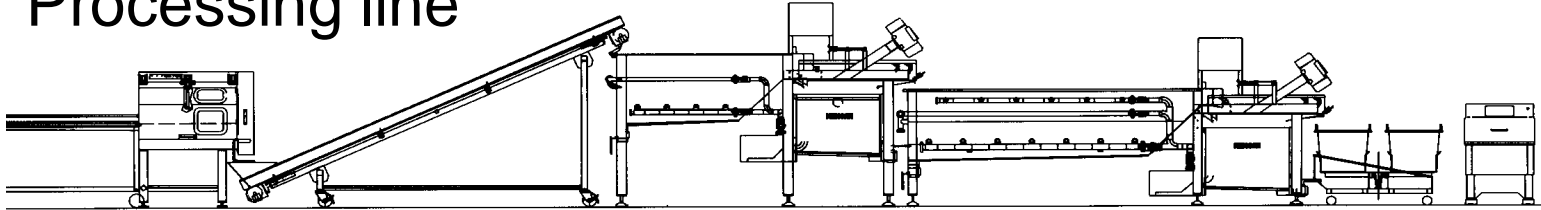
## Draining

The process should remove at least the same amount of that the product retained during processing (slight dessication is better)





## Processing line



## Packaging of Fresh-cut F&V

Use polymeric film (polypropylene 25-40µm thick, oriented polypropylene)

### Goals:

#### Preserve quality

- Reduce moisture loss
- Establish modified atmosphere (MA) around the produce
- Protect the fresh-cut F&V from external, physical, mechanical and biological forces (pathogens contamination)
- Facilitate transport, handling, storage, marketing

**Avoid:** pathogen contamination, residues, negative appearance  
(The slightest amount of a defective product in the package is unacceptable)

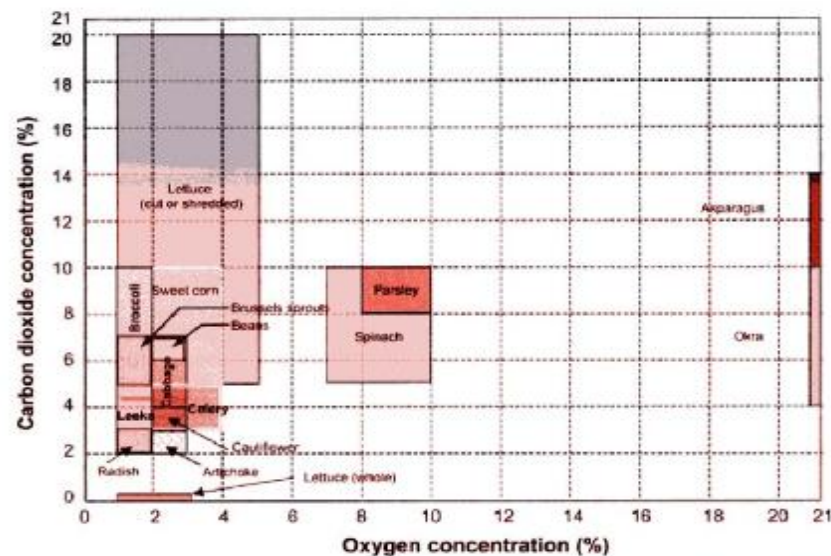


Fig. 1. Recommended oxygen and carbon dioxide ranges for the storage of some harvested vegetable commodities (Saltveit, 2002).

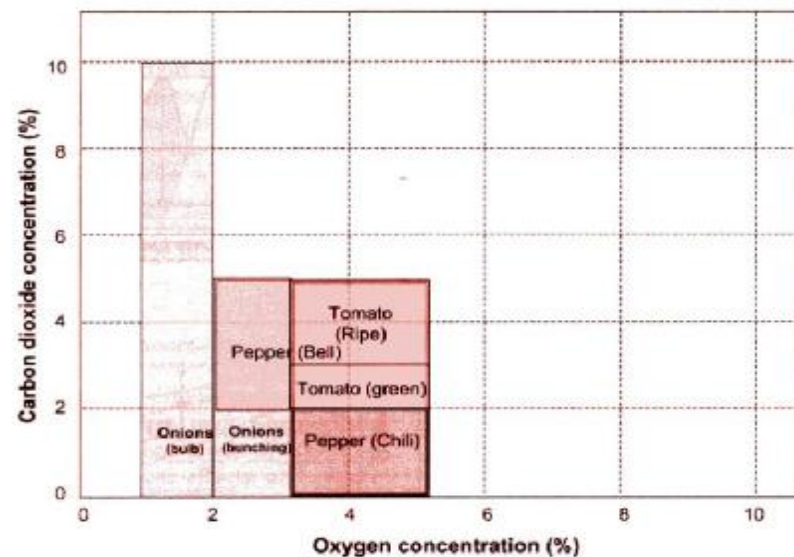
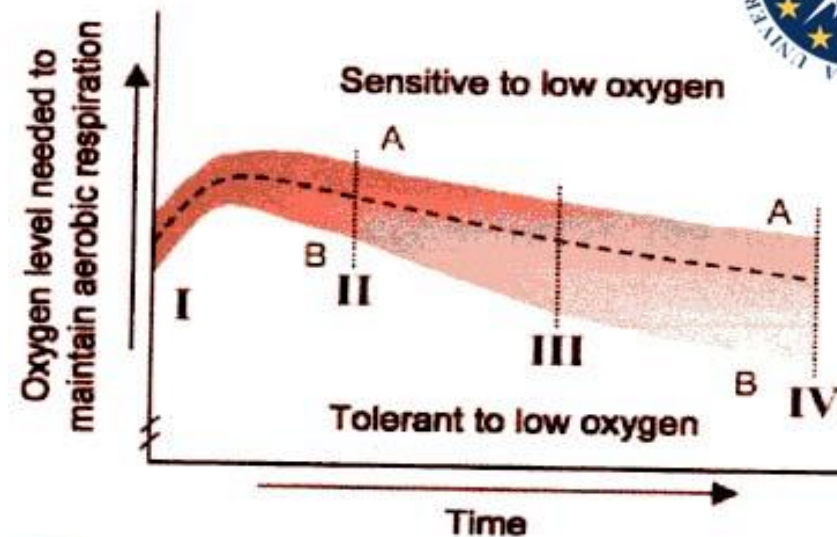
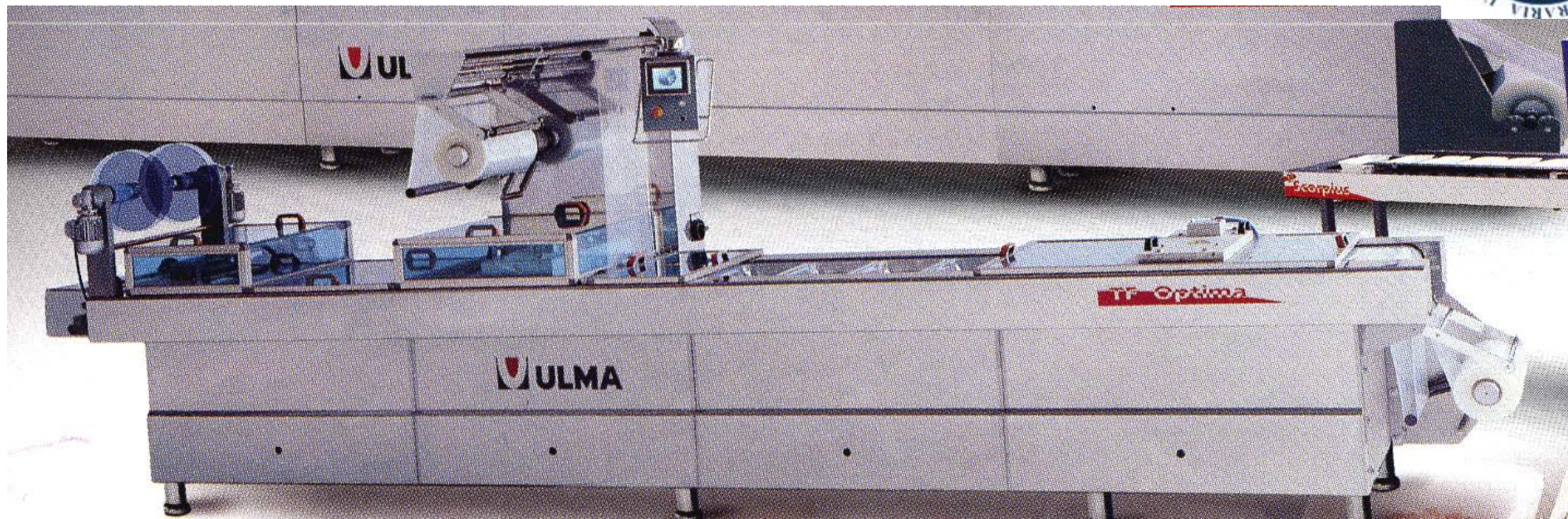


Fig. 2. Recommended oxygen and carbon dioxide ranges for a few harvested vegetable commodities showing differences within individual commodities (Saltveit, 2002).





# Packaging machines





# PRESERVATION METHODS

For fresh-cut fruits and vegetables

Microbiological and enzyme considerations to prevent spoilage





# Preservation methods-extend shelf life of fresh-cut F&V

## Microbial and enzyme considerations to prevent spoilage

To inhibit the growth of microorganism

Avoid to use extreme treatments

Apply the "hurdles or barrier concept" (of using less than extreme preservation treatments in a logical sequence to provide like- fresh quality)

Suitable combinations of growth-limiting factors

Packaging-prevent the entry of microorganism

Storage at refrigerated optimum temperature

Heat treatment

Preservative (antioxidant) added





To implement heat treatments at:

Pre-cut stage

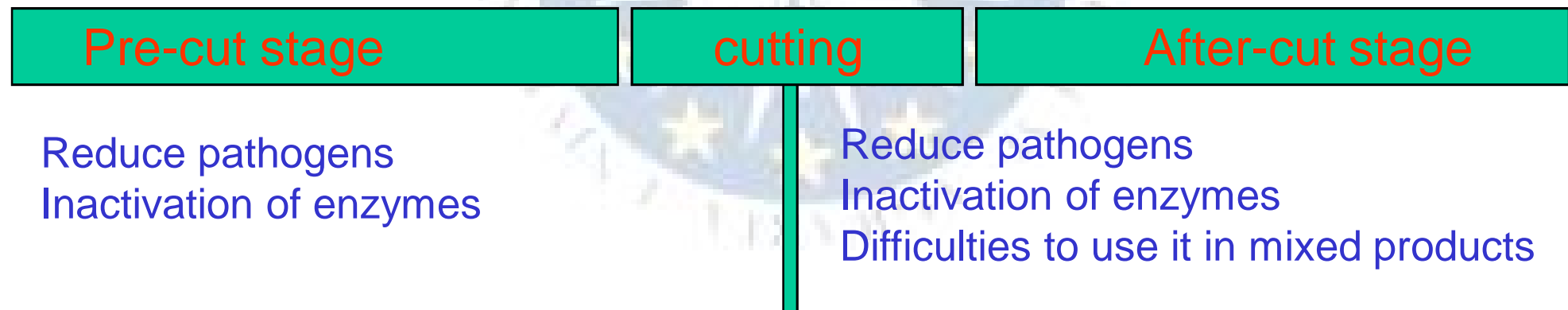
After-cut stage

Critical points to consider:

The product should still exhibit like-fresh characteristics

Initial temperature important (e.g. 0° .....20°C)

After heat treatment remove extra heat --> storage temperatures





Pre-cut stage

cutting

After-cut stage

Enzymes can be inactivated by high  $T^{\circ}\text{C}$ . Most of enzymes of fresh-cut F&V have an optimum temperature in the  $30\text{-}50^{\circ}\text{C}$  temperature range. This means short heat treatments in the lower range to reduce pathogens may possibly increase the activity of certain undesirable enzymes..

**Problems** for control of injurious enzymes in fresh-cut F&V by heat alone. It is difficult to inactivate enzymes and retain fresh quality. Additional hurdles must be included



## Pre-cut stage

Treatments to reduce pathogens and enzyme activities

Heat treatments (heat shock) to reduce wound response and stop pathogen breakdown

1-MCP (inhibits ethylene sensitivity) (as a pre-treatments in apples)

## cutting

Alternative treatments to reduce microbes and enzyme activities

Selecting cultivars with good-uniform responses

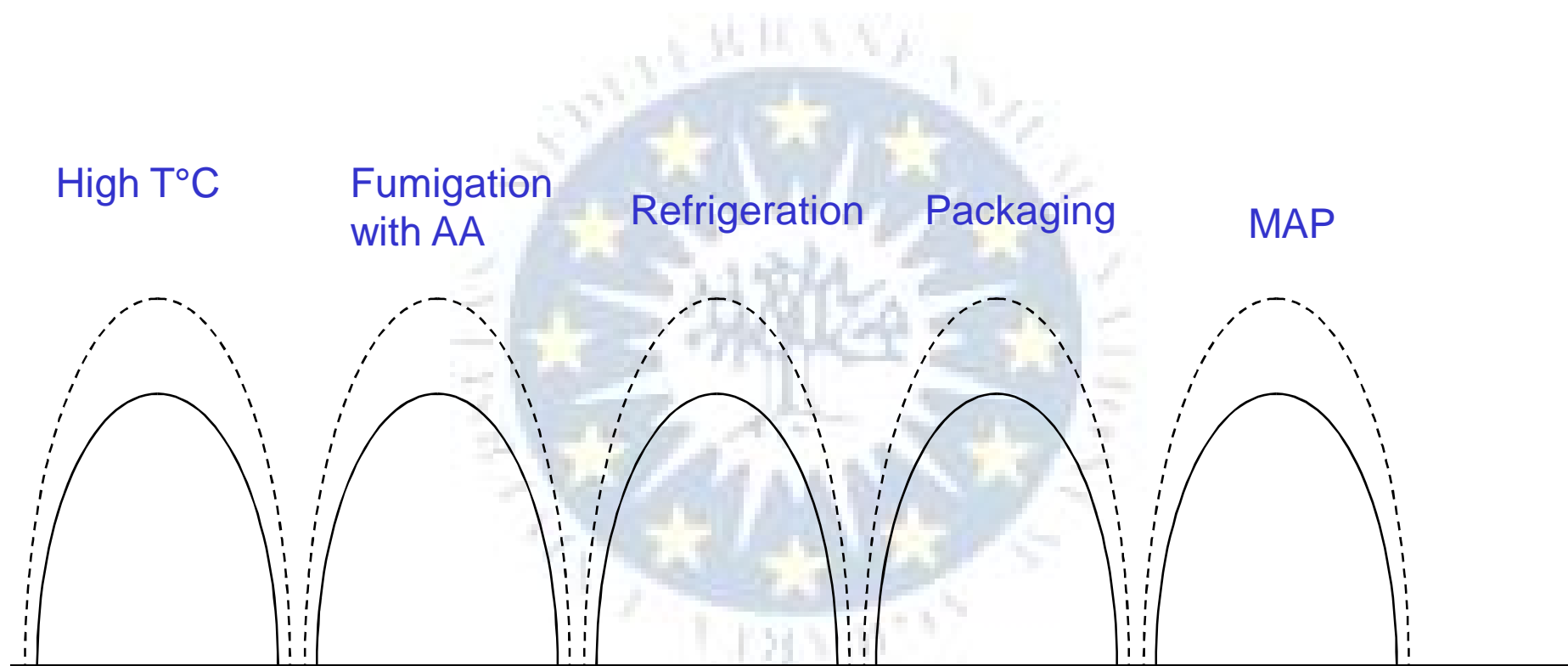
Heat treatments (heat shock) to reduce wound response and stop pathogen breakdown

Fumigation with volatile compounds

- Acetic acid
- Essential oils
- Methyl jasmonate

Optimize MA packaging

Edible coatings (sucrose esters, pullulan etc.)

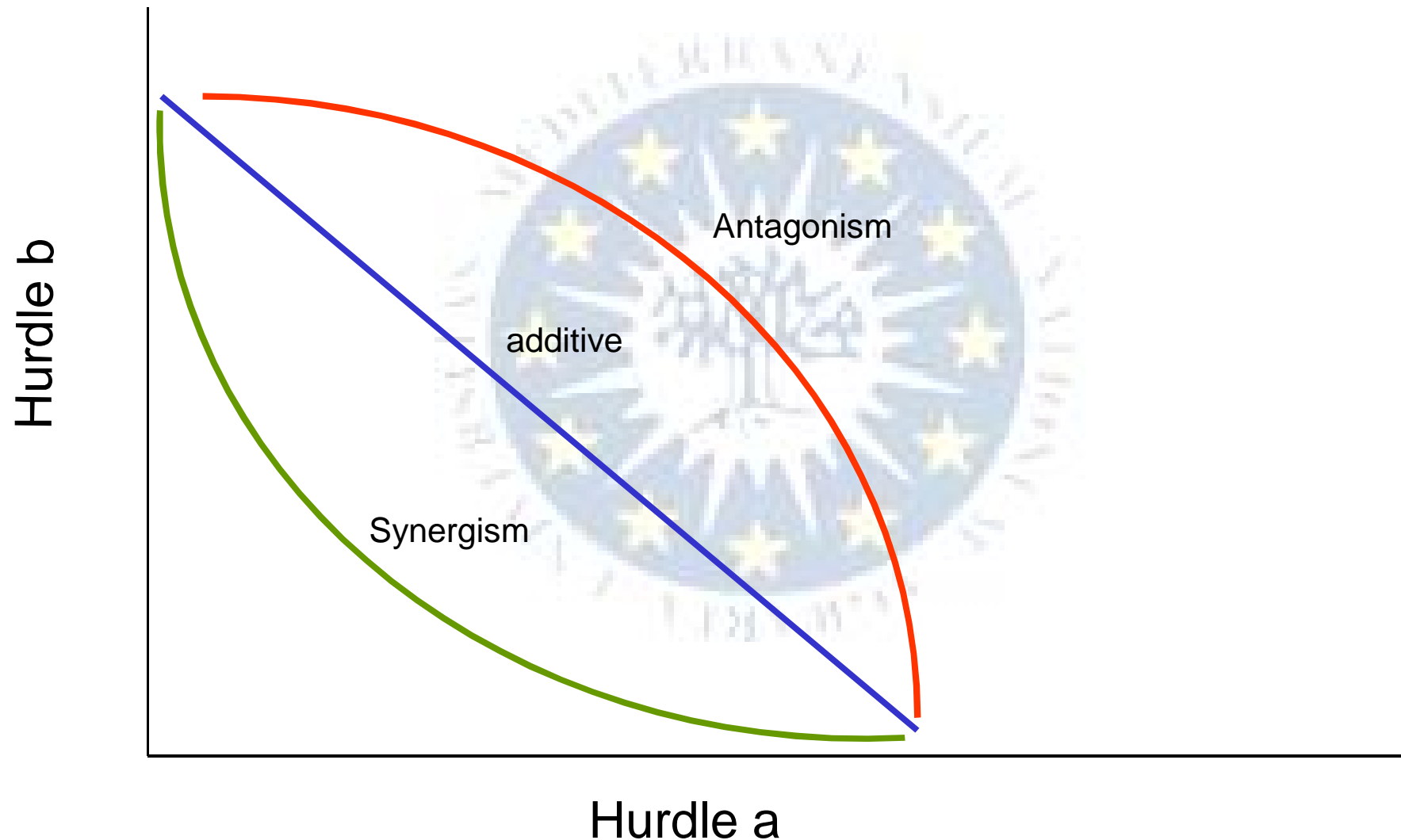


The concept of hurdle technology



## The concept of combining hurdles

The hurdles provided must at minimum be additive in action preferably synergistic and not antagonistic





# Summary

Fresh-cut fruits and vegetables are **highly perishable** due to damaged and exposed tissues and lack of protective skin.

There are **advantages** (great demand in the market ready to eat ready to cook) and **disadvantages** (limited shelf life, high microbial load, high purchasing cost) in the marketing of fresh-cuts.

Control of the **wound response** and the **microbial stability** are the keys to quality of fresh-cut F&V.

**Microbial growth** is controlled by: good sanitation, proper moisture, temperature, and other factors (CO<sub>2</sub>, O<sub>2</sub>) management.

Temperature, atmosphere, RH, and sanitation must be regulated to maintain quality of fresh-cuts.

**High quality** can be maintained by selecting produce at proper maturity, and controlling deterioration with low temperatures and MA.



## Summary (cont.)

For safety and greatest retention of sensory quality and nutritional quality products must be distributed and marketed in the cool chain.

Refrigeration and packaging of fresh-cut are mandatory for the fresh-cut products. By using the proper technology ensure ultimate consumer safety (nutritional and healthy quality, convenience at minimum cost).

In design of a processing line consider the initial investment, the cost of operation, the time, the labor and the water to be used for cleaning.

In packaging of fresh-cut F&V use polymeric film to reduce moisture loss, establish modified atmosphere (MA) around the produce, protect the fresh-cut F&V from external, physical, mechanical stress and from pathogens contamination.

To inhibit the growth of microorganism: avoid to use extreme treatments, apply the "hurdles or barrier concept" (of using less than extreme preservation treatments in a logical sequence to provide like- fresh quality)

Alternative treatments have been studied to control microorganisms (Heat treatments, fumigation with acetic acid, edible coatings etc.), however more research is needed to implement these methods in commercial scale.